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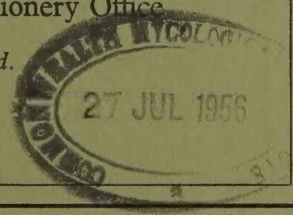

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# N.A.A.S.
# QUARTERLY REVIEW

*The Journal of the National Agricultural Advisory Service*

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## REVIEWS AND ABSTRACTS

In this section of the N.A.A.S. Quarterly Review, it is intended to survey current research and experiment in agriculture, horticulture and the allied sciences applicable to the work of the National Agricultural Advisory Service. It will not be possible, of course, to cover more than a small part of this wide field in each issue.

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# Deterioration of Sea-flooded Soils in Lindsey, Lincolnshire

T. G. HEAFIELD
*National Agricultural Advisory Service, East Midland Province*
and
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FEW PEOPLE will forget the sea flood disaster of 1953, when high tides broke through our east coast defence system. In Lindsey, 25,000 acres of land were flooded, livestock were swept away, and damage to property, growing crops and stores was severe.

A full report of the early effects of the catastrophe was given by J. W. Blood in No. 27 of this REVIEW*. Since then, highly significant effects and changes have become apparent. Chief among these is soil breakdown which has occurred over the whole area, varying in severity according to the clay content of the soil. In this report, soils have been divided into three main groups: sands, silty loams, and clays.

## Sands

The sands consist predominantly of fine sand. They have now ceased to be free draining and suffer temporary "ponding" or waterlogging. No detailed examination of this group has been made, since the sands represent only a small proportion of the flooded land.

## Silty Loams

These soils, formed by marine deposition, are virtually stoneless, with a typical mechanical composition of 3 per cent coarse sand, 39 per cent fine sand, 27 per cent silt and 20 per cent clay. Before the flood the pH range of the soil was 5.8-7.2, but by September, 1955, it was 8.0-9.2, due to a release of sodium ions from the clay complex. Where there was no remedial treatment, soil reaction is highest and is increasing, but where powdered gypsum has been applied, reaction has been stabilized, or even depressed by as much as one pH unit.

Gypsum applications, however, have not completely halted soil breakdown, even where combined dressings over $2\frac{1}{2}$ years have been as much as 6 tons per acre. Except in the top 3 in. or so of the soil, the stabilizing effect on structure has been slight; structural breakdown with deflocculation of clay and its subsequent movement down the profile being still apparent. By September, 1955, a fairly good crumb to

*The 1953 Sea Flood Disaster in Lindsey, Lincolnshire. J. W. BLOOD. *N.A.A.S. Quarterly Review*, 1955, **27**, 125-34.

sub-angular blocky structure, seemingly stable, occurred in the soil from the surface down to about 3 in. At the base of this horizon, there were patches of platy structure. Extending downwards to about 13 in. below this occurred an indurated horizon penetrated by strong vertical cracking (possibly a result of the long dry summer). Under this was the parent material of laminated fine sands and silts.

Although blocky structures dominate these profiles, a very strong, coarse, blocky type predominates in the indurated zone, with a fine to medium angular blocky structure adhering to the faces. Originally, these soils had a medium to fine angular blocky structure, but this has now been completely incorporated in the coarse units and can no longer be seen.

Clay, silt and colloidal organic matter have been mobilized within the profile. Redeposited silt with some fine sand can easily be recognized down to about $4\frac{1}{2}$ in., whereas deflocculated clay can be seen down the structure faces to more than 12 in.; mechanical analyses confirm these observations. Evidence of downward movement of dark-coloured colloidal organic matter appeared on the structure faces in the upper parts of the profile. Analysis indicates that the major portion of the mobilized clay is, so far, coming from the top 2 or 3 inches of the soil.

As yet, none of the deflocculated clay has been carried into the ditches surrounding fields of this soil type. Most of this land has never been under-drained, but this may become necessary in the future if water-logging, caused by clay and silt shift, becomes pronounced.

### Clays

The heavy clay soils of fluvial origin are stoneless and uniform in character. They have a typical mechanical analysis of 2 per cent coarse sand, 12 per cent fine sand, 32 per cent silt and 50 per cent clay. Before flooding, these soils had a stable, medium to fine, sub-angular blocky structure in the top soil, overlying a well-developed prismatic B horizon.

As long as any electrolyte, especially sodium chloride, remained within the solum, there were no obvious changes. By May, 1954, however, when the sodium chloride had been leached from the A horizon, the surface showed pronounced structural breakdown with differential movement of silt and clay down the profile. Closely following this phenomenon there was a slight clay contamination of the drainage water in the field ditches, but during September 1954, the tile drains were discharging a clay slurry into the open ditches, often to depths of 2 ft or more. The surface soil showed a marked decrease in clay content; on drier sites, silt and fine sand laminations were readily visible at various levels down to the top of the B horizon. Generally, however, a wet, tenacious, structureless horizon of deflocculated clay and silt occurred from 2 in. down to the top of the prismatic B horizon (approximately 11 in.). Where decomposed organic manure and vegetable matter was present, this combined with the deflocculated clay to form a blue-black colloidal suspension.

During 1955, the soils dried out, and surface cracking was widespread by mid-summer. However, the structureless horizon dried out very slowly, and it was not until July that cracks penetrated this layer. The disposition of these cracks bore no relationship to those that existed in the natural prismatic structure of the B horizon.

There were marked signs of downward clay migration along the structure faces of the B horizon, producing patchy, polished faces formed by recent deposition of darker brown clay. These features were apparent down to tile drain level, usually at 2 ft to 2 ft 6 in., and the tiles showed varying degrees of clay-infilling, some of them being completely blocked. Where water in the ditches has covered drain outlets, a more rapid deposition of deflocculated clay has taken place. In some places, drains of 2½ in. diameter tiles have been completely blocked 14 months after installation. Flocculation of the clay in both tile drains and ditches subsequently occurred due to the presence of sodium chloride, which apparently comes from the inner portions of the soil prisms as the downward flow of soil water greatly diminishes.

The structural conditions described persisted until August, 1955, when there was an abrupt change. Radical alteration of the structural profile was effected by the penetration of cracks down to 15-18 in. and a fusion of the prismatic structure in the B horizon. A typical solonetz development took place, giving a thin friable surface layer, usually 1-2 in. thick, covering very strongly developed columns with rounded tops. The columns were extremely stable and could be lifted out intact to the full depth of the major cracks.

### Effects on Agriculture

The changes in the agricultural properties of the flooded soils are, in the main, a reflection of soil deterioration due largely to textural differences. On the sands, there is little evidence of adverse effects on crop yields and normal cropping was resumed by January, 1954.

Silty loams are now far more intractable, and tend to work as heavy soils. Since the flood, cropping rotations have been completely upset by continuous cropping with cereals, especially barley. Generally satisfactory yields have been obtained, but only at the expense of heavier fertilizer applications—a condition common over all the flooded area. All crops have much shallower root systems, and fanging of root crops is severe. Newly-sown leys show a marked lack of vigour. Only old grassland appears to withstand the effects of flooding to any great degree.

Heavy clay soils have become increasingly difficult to work, and the formation of the wet, structureless horizon with waterlogging in low places has restricted all cultivations. Crops, where sown, have been very patchy due to killing by standing water. Infestation of these patches by Black Grass (*Alopecurus* sp.) has become a serious problem. These conditions have arisen because most of the land was far too wet to permit gypsum application after winter sowing.

Much of the old arable soil grew promising crops, but final yields were disappointing. Many poor crops had to be ploughed in and the land fallowed. Freshly ploughed-out old pasture has proved by far the better soil for arable purposes. To a large degree it has maintained a good structure and yields have been good. Even on these soils, however, it is possible to detect soil breakdown and clay shift.

A serious problem is the condition of the ditches. In many places, the formation of columnar soil structure has caused the collapse of ditch banks. This has added to the difficulties arising from the clay deposition from drainage waters. Ditches which were cleaned out only 12 months ago now require further cleaning to keep them working efficiently. Tile drains, especially the laterals, present another problem, for many are now full of flocculated clay. Cleaning and freeing is essential, and this should preferably be done with the least possible disturbance of the soil above the tile, to avoid increasing breakdown and clay shift.

In addition, there is a general need in the area for greater tractor power and heavier tackle to carry out cultivations.

The fundamental work for this report has been done in collaboration with J. W. Blood and E. Crompton of the Soil Survey of England and Wales, Rothamsted Experimental Station. Analytical and experimental data, together with full discussions of the problems outlined, will be published in the near future.

# Hormones and Lactation

A. T. COWIE

*National Institute for Research in Dairying, Shinfield, Reading*

ENDOCRINE GLANDS and their hormones play a very important role in the regulation of the reproductive processes, of which lactation is a phase. Before discussing the function of the various hormones in lactation, it may be helpful to consider briefly what is meant by an "endocrine gland" and a "hormone", since these terms are not always clearly understood. The word "hormone" is now being used, moreover, in fields other than animal physiology, with its original meaning somewhat modified.

## Glands and Hormones

A *gland* is an organized collection of cells in the body which, in addition to carrying out the metabolic processes necessary for their own existence, manufacture from materials in the blood a specific substance or *secretion*. There are two distinct types of gland: the *endocrine* or gland of *internal secretion* which passes its secretion directly into the blood stream, and the gland of *external secretion* whose secretion does not enter the blood, but is passed through a *duct* to the outside of the body (e.g., mammary gland) or to a cavity communicating with the outside of the body (e.g., salivary gland).

The secretion of an endocrine gland consists of one or more *hormones*. These hormones are carried in the blood through the body, and influence the rate at which cellular activities proceed in other glands or organs, without themselves contributing important quantities of energy or matter to the process. An endocrine gland can function to some extent as an independent unit, but the activity of each gland is influenced to a greater or lesser extent by the hormonal activities of the others. The main regulating gland of the endocrine system is the anterior pituitary gland, whose hormones are responsible for maintaining the proper level of function of the other endocrine glands. However, even the anterior pituitary is partially controlled in its functions by the hormones from the subordinate glands.

Like the nervous system, the endocrine system is a mechanism concerned with the co-ordination of functions of the body.

In recent years, a large number of hormones have been isolated, their chemical structure has been established, and some have been made artificially in the laboratory and factory. A few of the hormones are readily available, and it is therefore of interest to consider whether there are any practical applications of the judicious use of such hormones in dairy husbandry.

Endocrine glands which participate in the regulation of lactation through their hormones are the *pituitary* gland—anterior and posterior lobes, the *ovaries*, the *thyroids*, the *parathyroids*, and the *adrenal* glands. In some species, certain cells of the placenta and uterine wall take on endocrine functions.

The hormones of the *anterior* pituitary which have to be considered in relation to lactation are *prolactin*, *growth hormone* (G.H.)—sometimes termed somatotrophin, *adrenocorticotrophin* (ACTH), and *thyrotrophin*. The two latter hormones act indirectly on udder function by maintaining the normal levels in the blood of the secretions of the adrenal cortex and thyroid gland respectively.

*Oxytocin*—the hormone of the *posterior lobe* of the pituitary—is the substance responsible for the contraction of the alveoli which results in milk ejection (the so-called "let-down" of milk).

Hormones of the ovary, *oestrogen* and *progesterone*, must also be taken into account, because they are responsible for the normal growth and development of the glandular tissue of the udder. The secretion of these hormones from the ovary is controlled by the *gonadotrophic* hormones from the anterior pituitary. The physiology of the gonadotrophic hormones has been fully dealt with by Dr. Hammond in a previous article in this REVIEW [17].

*Thyroxine*—the hormone of the thyroid—influences the intensity of activity of the gland cells in the udder and indeed in body cells in general. Associated with the thyroid is a small gland—the parathyroid—whose hormone appears to have some effect on maintaining milk secretion and on the calcium and phosphorus metabolism of the udder.

The hormones of the adrenal, in particular those of the outer rind or the cortex of the adrenal—*cortisone*, *cortisol* (or *hydrocortisone*) and *aldosterone* are essential for normal lactation; they regulate protein and carbohydrate metabolism, and the water and electrolyte balance of the body.

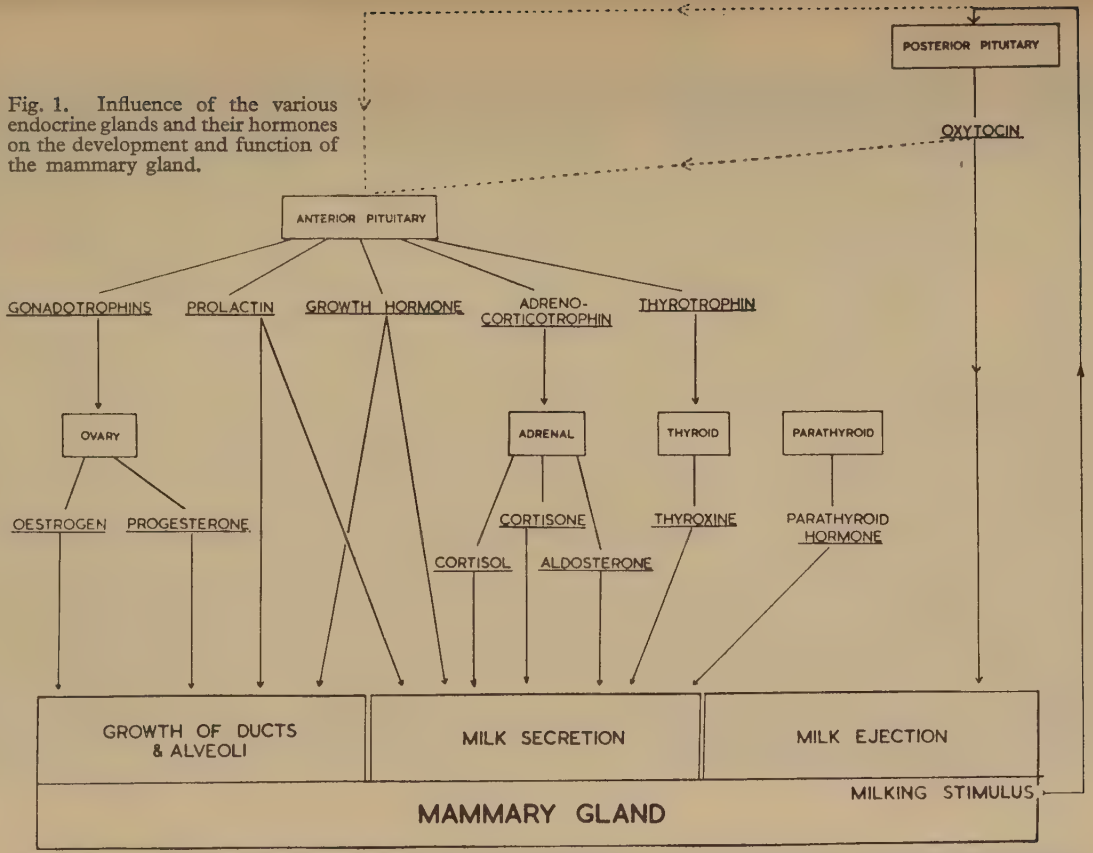
In some species the placenta and the lining of the uterus can take over endocrine functions and produce a prolactin-like substance and possibly also oestrogen and progesterone. So far, however there is no evidence that this occurs in the cow.

The processes of udder growth and lactation can now be considered with the respective roles which the above hormones play. A simplified summary of most of the information at present available on the role of hormones in these processes is given in Fig. 1.

## Mammary Development

In the heifer, the glandular tissue in the udder consists of immature duct systems and cisterns. During pregnancy, the further development of the udder is stimulated by the presence of increasing quantities of oestrogen and progesterone in the circulation. We know little about the actual level of these ovarian hormones in the cow during pregnancy, but there is much indirect evidence that they are essential and responsible

Fig. 1. Influence of the various endocrine glands and their hormones on the development and function of the mammary gland.




*The two possible routes by which the milking stimulus affects the anterior pituitary are shown by dotted lines. The actual relationship between the anterior pituitary and target glands (ovary, adrenal, etc.), is more complex than is shown here, since excessive hormone production by a target gland may have an inhibitory effect on anterior pituitary function.*

for the stimulus to udder growth. It is also known that before these hormones can act there must be present in the blood certain hormones of the anterior pituitary—prolactin and probably the growth hormone—but further research is necessary to establish with certainty which anterior-pituitary hormones are involved.

## Lactation

It is now customary to make a clear distinction between the two main phases comprising lactation—namely, *milk secretion* and *milk removal*. By *milk secretion*, we mean the process of milk formation within the cells of the mammary alveoli and the transference of this secretion from the cytoplasm of the cell into the interior of the alveolus. As we have already noted, the ability of the alveolar cells to secrete milk is dependent on the presence in the blood of certain hormones from the anterior lobe of the pituitary—prolactin, growth hormone, and possibly others—as well as the hormones of the adrenal cortex, thyroid and parathyroid, if the full milk-producing capacity of the cells is to be maintained. The hormones of the ovary apparently play no direct role in maintaining lactation; indeed, removal of the ovaries may prolong lactation. Ovarian hormones may, however, affect milk secretion indirectly by altering the rate of secretion of the hormones from the anterior pituitary.

The second phase of lactation—*milk removal*—refers to the process whereby milk is ejected from the alveoli and fine ducts, where it is held by capillary forces, into the large ducts and cisterns where it can be readily obtained by the milker. The active expulsion of milk from the alveoli and fine ducts is now termed *milk ejection* in preference to the older and misleading term "let-down" of milk. The hormone oxytocin, liberated reflexly from the posterior pituitary by the milking stimulus, causes the contraction of a network of branched cells lying on the outer surface of the alveoli and so forcefully expels the milk from the alveoli into the ducts and cisterns. The oxytocin in the circulation is rapidly inactivated. The bearing of these facts on milking procedure is now well known and we need not discuss here the desirability of conforming to a strict routine and of rapid milking once milk ejection has occurred. Further information on the physiology of milking will be found in the writer's recent review [8].

Numerous theories have been put forward to explain the onset of copious milk secretion at calving. We cannot consider all these theories in detail, but one view that seems to fit most experimental observations (see [13]) is that the onset is associated with a sudden fall in the progesterone and oestrogen blood levels at parturition. Now, in certain ratios, these two hormones can largely prevent the release of the hormones from the anterior pituitary necessary for milk secretion, and this inhibitory action is believed to take effect during pregnancy. At parturition, the ratio of these two substances to one another in the blood is suddenly altered, and the pituitary comes almost entirely under the influence of small quantities of oestrogen in the circulation which

stimulate the release of the lactogenic hormones. Once lactation has been initiated, its maintenance depends largely on the stimulus of regular milking. We have already noted that the milking stimulus releases the oxytocin from the posterior pituitary necessary for milk ejection, but this stimulus is also responsible for the release of the hormones from the anterior lobe essential for the maintenance of the secretory function of the alveolar cells. Recent investigations in the Physiology Department of the National Institute for Research in Dairying have indicated that the release of certain anterior-pituitary hormones may be brought about by the direct action of oxytocin on the cells of the anterior pituitary [3]. If subsequent work confirms these tentative findings, a simple explanation is at hand of how the phases of milk secretion and milk ejection are co-ordinated. The oxytocin liberated by the milking stimulus would thus not only cause milk ejection but would liberate from the anterior pituitary the hormones necessary for the secretion of further milk by the alveolar cells.

Further details of the roles of hormones in lactational physiology and biochemistry will be found in the recent review by Folley [13].

### Hormones in Dairy Husbandry

Although certain applications of hormone administration in dairy husbandry may be experimentally possible, they are not at present feasible in practice because the hormone is too expensive or is not commercially available. The present supply position is as follows:

| Readily Available | Available in Small Quantities and Expensive | Not Available Commercially |
|---|---|---|
| Oestrogen (synthetic) | Progesterone (Gt. Britain) | Prolactin |
| Thyroxine | ACTH | Growth Hormone |
| Progesterone (U.S.A.) | Cortisone | Thyrotrophin |
| | Cortisol | Aldosterone |
| | Oxytocin | |

In administering hormones, the complex functional inter-relation of the endocrine glands must be kept in mind. Altering the blood level of one hormone will inevitably alter the levels of other hormones and so the effect of administering a hormone to an animal is never just the simple one of increasing the blood level of that hormone *alone*. For example, if we give thyroxine to a cow, it will supplement the natural level of this hormone in the blood, and the anterior pituitary will respond to this higher level of thyroxine by reducing its output of thyrotrophin. This reduction in thyrotrophin will reduce the activity of the thyroid and less thyroxine will be secreted. Thus, if the dose of thyroxine is not too high, the fall in the secretion rate of thyroxine may completely compensate for the daily dose of thyroxine, and the blood level of thyroxine will be restored to normal. On stopping the

thyroxine, however, there will be some delay before the resulting fall in thyroxine level in the blood causes the pituitary to increase its output of thyrotrophin, thus increasing thyroid activity and eventually restoring the blood level of thyroxine to normal limits. Administration of hormones must, therefore, be carried out with care or there may be unexpected side-effects. With these limitations in mind, the possible application of hormone therapy in farming can be considered next.

## INDUCED LACTATION

One of the first applications of hormones in dairy husbandry was the induction of lactation in heifers and cows with synthetic oestrogen [14, 18, 21 and 10]. This was made during war-time in an effort to bring into lactation cows and heifers which had failed to get in calf; the object of this treatment being to make it economical to keep these animals while further attempts were being made to overcome their infertility. The procedure most generally adopted was to implant tablets of synthetic oestrogen beneath the skin. Such tablets are only very slowly absorbed and so the implanted animals receive low dosages of oestrogen over long periods. As a result, there was generally a rapid development of the udder and a milky secretion could soon be withdrawn. Often the quantity of milk increased rapidly and, within a few months, some animals were giving between 1 and 2 gal per day. It was found necessary to remove the residue of the oestrogen tablets when a peak yield was reached, otherwise excessive oestrogen was absorbed and a rapid depression of the yield was produced. In the more successful cases, yields of 3 gal per day were obtained which persisted for a period equivalent to a normal lactation. At the outset the secretion was colostral in nature, but by the time a daily yield of 5 lb was reached, the milk was normal in composition. No significant quantities of oestrogen were found in the milk. Extensive experiments were carried out on this procedure, but it proved unsuited for general application for the following reasons:

1. There were great individual differences in the responses obtained; some animals might give 3 gal per day whereas others failed completely to give any lactational response.
2. It was impossible to tell at the start of treatment which animals would respond and which would not. In general, only one out of every two animals treated reached a maximum yield of $1\frac{1}{2}$ gal per day.
3. Undesirable side effects resulted from the oestrogen treatment. During the period the animals were carrying the implants they showed oestrous symptoms at frequent intervals, and in some cases became quite nymphomaniac in behaviour. For this reason it was necessary to keep treated animals in isolation, otherwise serious injuries could arise, such as fractures of the pelvis and femur [7].

At the time, it was thought that the many failures were due to the fact that only oestrogen was being administered, when in fact, both oestrogen and progesterone are necessary for normal mammary growth. In order to investigate this possibility, a series of experiments on goats were carried out by the Physiology Department of the N.I.R.D. Goats were used because it was possible to obtain sufficient quantities of progesterone for their treatment. To control more accurately the dose levels of the hormones administered, the goats were given daily injections of solutions of oestrogen and progesterone in oil. In addition to studying the lactational performance of these animals, very extensive studies were carried out on the microscopic structure of the udders so developed. We need not go into the results of these extensive experiments in any detail, but two general conclusions can be drawn from them. Firstly, the combined use of progesterone and oestrogen gives more uniform milk yields. The yields obtained with the combination of hormones were not much in excess of the best obtained with oestrogen alone, but the responses from animal to animal were more consistent. Secondly, the structure of the udder is much more normal when progesterone is administered with oestrogen [9 and 2].

While these experiments were in progress, a new process was developed in the U.S.A. for making progesterone synthetically and it became available in quantities sufficient to use in the large ruminant. Experiments were carried out at the Michigan State University by Reineke, Meites, Cairy and Huffman [22] using tablet implants of oestrogen and progesterone in cows. Two of their animals gave record yields of $4\frac{1}{2}$ and 8 gal per day. These experiments aroused considerable interest. Similar experiments have been made by Cowie, Flux and Folley (unpublished work) both at the N.I.R.D. and in co-operation with certain farms. Unfortunately, results as spectacular as those of Reineke, Meites, Cairy and Huffman have not been obtained. It is true, however, that with the combined progesterone-oestrogen therapy higher yields have been obtained in the bovine, than with oestrogen alone. In addition, the number of non-responding animals is smaller and the appearance of frequent and irregular oestrous symptoms is greatly reduced and often absent. Moreover, even where the lactational response is a failure, the animals tend to improve in "condition" with the treatment and are therefore worth more at slaughter. Further research work is required, particularly on methods of administration (e.g., the use of crystal suspensions of hormones) and on the most suitable dose levels of both oestrogen and progesterone, before the procedure can be generally applied in practice for the induction of lactation in sterile cows and heifers.

The use of synthetic oestrogens to induce lactation in barren ewes has recently been reported by McPherson [20], who found that lactation could be successfully induced by a single dose of 40 mg stilboestrol dipropionate, and that within 15 days of this injection, sufficient milk was secreted for the ewes to be used as foster mothers.

## STIMULATION OF MILK YIELD

Attempts have been made to increase the normal milk yield of the cow by various hormonal treatments, the most extensively investigated being the use of thyroxine or thyroid-active substances incorporated into cattle cake.

(*a*) *Thyroxine.* Graham showed in 1934 [16] that by feeding dried thyroid gland or by injecting thyroxine, the milk yield of cows could be increased. At that time, the treatment could not be applied because of the expense of the thyroxine and dried thyroid. However, some years later it was found that certain iodinated proteins possessed thyroxine-like activity when given in the feed, and several large-scale experiments were carried out [5]. Later, a new method of synthesizing thyroxine was developed and thyroxine itself became readily available. It was then shown that thyroxine need not be injected because it was active when fed to cows [1]. Since the use of thyroxine to boost milk yield has been intensively investigated, it is possible to come to fairly firm conclusions regarding its value. There is a wide variation in the degree of stimulation of milk production resulting from the administration of thyroxine or of thyroid-active substances; on the whole, a better response is obtained during the decline of lactation than at the peak or end of lactation. Moreover, it has been found that the use of thyroxine or thyroid-active substances during the first to third lactations is inadvisable, for the boost in yield obtained is largely cancelled out by a shortening of the lactation period. The best results are obtained when the thyroid-active substances are administered for relatively short periods (i.e., not exceeding two months). Short-term administration at favourable periods can result in dramatic increases. Unfortunately, because it takes some time for the animal's own thyroid to recover from its quiescent state, when administration ends there is often an equally spectacular decrease in yield, which is due to the sudden fall in thyroxine level in the blood. On average, there is a net gain in yield of about 3 per cent. At present the incorporation of thyroid-like substances in cattle feed is prohibited by law. It is unlikely, however, that the procedure would be of great practical importance except, perhaps, to increase production at times when the price of milk is high. The effect of thyroxine or thyroid-like substances is probably not a specific one on the alveolar cells but is part of the effects of thyroxine on the general metabolic rate. Further details of thyroxine administration to cows will be found in the papers by Blaxter [4], and Leech and Bailey [19].

(*b*) *Growth hormone.* Early experiments, both in this country and in Russia, demonstrated that increases in milk production could be obtained by giving injections of extracts of the anterior pituitary to lactating cows. The best responses were obtained when cows were treated during declining lactation. Later experiments in this country by Folley and Young and their colleagues [24 and 13] demonstrated that this

response was largely due to the growth hormone present in the extracts and they showed that preparations of highly-purified growth hormone gave similar increases in yield. This yield-boosting effect of growth hormone has since been confirmed by several investigators. Of considerable interest are the recent experiments in New Zealand of Brumby and Hancock [6], who studied the effect of daily injections of purified growth hormone in identical twin cows for a 12-week period over the peak phase of lactation, and a 4-week period over the end phase of lactation. In both trials, a very substantial increase in milk yield was obtained.

Another interesting effect of growth hormone has recently been observed by Shaw [23], who reported that the administration of growth hormone to two sets of identical twin heifers for a week or two before and after parturition resulted in an increase in yield throughout the subsequent lactation. If Shaw's results are confirmed it would appear that growth hormone must act in such cases by stimulating further growth of the udder, otherwise it is difficult to account for the prolonged influence on milk yield.

It is evident, therefore, that growth hormone appears to play a very important role in lactation in the cow and that in cases of low yield there may be a deficiency of growth hormone in the circulation. At the present time, growth hormone is only produced in small quantities for research purposes and so no large-scale trial of this material is possible. It is, however, a hormone which may in the future be successfully exploited in the dairy industry.

(*c*) *Prolactin* has little or no effect in boosting lactation in the cow. This does not imply that the hormone plays an unimportant role in milk secretion but merely that in most cows there are sufficient amounts present in the blood for its maximum effect to be exerted on the mammary gland.

(*d*) *Adrenocorticotrophin* (ACTH) when injected into normal cows tends to produce a decrease in yield. Presumably this acts by releasing excess quantities of hormones from the adrenal cortex, since slight drops in yield have been reported after the injection of cortisone into normal cows. Although ACTH does not, therefore, appear to increase milk yield, cortisone and cortisol are proving of considerable value in the treatment of ketosis in cows. In such cases there is often a rapid improvement in milk yield a few days after treatment.

(*e*) *Thyrotrophin.* As would be expected, this hormone increases milk yield by increasing the output of thyroxine from the thyroid.

(*f*) *Oxytocin.* The intravenous injection of this hormone will produce milk-ejection ("let-down") within a minute. It has so far no practical applications in dairy husbandry. Therapeutically it may be useful in sows in which there is a failure of milk ejection after farrowing.

ENRICHMENT EFFECT

Prolonged increases in the fat and non-fatty-solids content of the milk of cows given single injections of oestrogen were reported by Folley [12]. Further investigations confirmed that this enrichment was a true increase in the yield of solids secreted, and not merely a concentration due to reduced secretion of water [15]. Further studies on the enrichment effect are at present being carried out at this Institute by Mr. J. B. Hutton. The dose level of oestrogen appears to be highly critical and no recommendations for general application can at present be made.

## Conclusions

In the last few decades, considerable advances have been made in the elucidation of the hormonal mechanism controlling lactation, but no spectacular uses of hormones in dairy husbandry have arisen. This, however, is scarcely surprising in view of the great complexity of the hormonal factors controlling lactation. The interpretation of experiments on hormone administration is not easy, and very carefully controlled experiments are essential before the final balance sheet of the benefits and disadvantages of any hormone treatment can be drawn up. This is very well exemplified by the extensive work on thyroxine where spectacular increases in yield must be balanced both against unusually rapid drops in yield after the treatment ends and against the shortening of the normal lactation periods.

It will be obvious that any hormone treatment should be thoroughly tested in properly controlled experiments before attempts are made to use it in farm practice, and it should be established that the proposed treatment is not detrimental to the health of the animals and that there is no risk to human health from the consumption of meat or milk from such animals. In short, the indiscriminate use of hormones in farm practice may be dangerous. It is unlikely that hormone administration will ever become routine in dairy husbandry under normal circumstances, but it may have most valuable applications in selected animals and in special circumstances. Nevertheless, our ever-increasing understanding of the hormonal control of lactation has been beneficial to dairy husbandry. The elucidation of the endocrine mechanisms involved in milk ejection, for example, has led to considerable modification of the general milking routine as practised in the cowshed, resulting in more efficient milking. This aspect has recently been dealt with by Dr. F. H. Dodd [11] in an excellent and comprehensive review.

Other advances may come when we know more about how various environmental conditions influence the endocrine system, and when it becomes possible to assay accurately and quickly the levels of the various hormones in the blood. When we can correlate differences in hormone levels with differing lactational efficiencies we may have useful data for selecting animals for dairy and breeding purposes.

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# Reviews and Abstracts

## Changing Views on Aphid Dispersal

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THERE ARE three major questions about aphid dispersal: why are migrations heavy in some seasons and not in others? What causes the "mass migrations" which occasionally fill the air with flying aphids? How far do aphids travel?

The answers are not so simple because all aspects of the dispersal process have to be considered. The first question really concerns population ecology (of which we know more about the elements, but little more about their interactions in nature, than we did twenty years ago) and the factors influencing the proportion of winged forms, exhaustively reviewed by Bonnemaison [1]. The second and third questions relate to events in the dispersal process itself; the considerable advances which have been made in this field form the subject of this article.

### Former Opinions on Dispersal

Until two or three years ago, the number of aphids being dispersed at any one time were thought to be controlled mainly by weather factors acting on the ability of the aphid to take-off. Many articles and books state, or imply, that migration takes place only when temperature is about 65°F or above, and when the relative humidity is below about 70 per cent and wind-speed not higher than 5 m.p.h. Most migration was thought to occur mainly in calm weather. These views were based on Davies' well-known experiments on aphid flight and the large catches in traps most common in calm weather [2 and 3]. We now know that this picture is oversimplified and erroneous.

Most work in the past has been done with one trap at 4-5 ft above ground level, emptied once a day or less often. This seriously limits analysis of the dispersal process—it gives no information about the immense reservoir of flying aphids in the upper air, which is of great importance. It cannot detect the causes of changes in aerial density, for these operate from minute to minute and hour to hour, rather than from day to day, and it neglects events on the plant which are in fact the beginning of the story.

The last few years have therefore seen a development of methods, in particular suction traps, which measure aerial density from hour to hour continuously (and even in shorter periods if necessary), not only at crop level, but up to several hundreds or even thousands of feet into the air. Changes in numbers dispersing have also been associated with changes in

numbers of alatae produced on plants over these short intervals and are thus linked with terrestrial ecology [16].

Only the bare outlines of the story and the problems it suggests are possible in this article: we must consider first the supply of alatae into the air on their first flight from where they are produced; what happens to them when they become airborne; their alighting, and subsequent flights, and their ability to choose their hosts.

## Variation in Numbers Taking-off

There are good reasons for thinking that most aphids in the air are fairly young and that those taking-off for the first time, or at least on occasions soon afterwards, often make a very substantial contribution to the total numbers in the air. Consider a well infested crop producing new alatae: *Aphis fabae* on beans in the summer is a good example, and most of the work has been done with it.

The last instar moults into the winged, parthenogenetic, adult female, which is soft and unable to fly until it has become flight-mature—a process lasting from 6 hours to 2 days and influenced mainly by temperature. The writer's unpublished work shows that, at least in a sheltered crop, the aphids fly as soon as they are mature, and any delay is due more to slower maturation than to unfavourable weather. Aphids do not, however, take-off at night, nor at leaf surface temperatures below about 17°C. Under experimental conditions a continuous wind may delay take-off for some hours; in nature it is unlikely to have more than a very temporary delaying effect, indeed, new moulted alatae of many aphid species can take-off in quite strong breezes, so great is the "urge" to fly [7].

It is extremely important to realize that most aphids taking-off from plants producing them *fly away*. They probably never return to the same plant, and only rarely to the same crop, for after the first take-off they fly upwards and get carried off on the breeze. Tree aphids may be an exception, but little is known about them in this respect [8].

## Flight Waves

If a trap is erected just above such a crop, the alatae departing on this first flight on a warm day usually come off in two main waves, one in the morning, one in the afternoon [15]. These waves of density above the crop vary in amplitude and intensity. On some days a single wave is often seen; sometimes several minor waves occur on the same day. This has little to do with variable flight behaviour, for aphids can fly in many kinds of weather; unpublished work by the writer and his collaborators show that it is basically due to variation in length of the maturation period. For example, the first wave in the morning is often (perhaps always) composed of the insects which failed to mature the day before but did so slowly overnight. Thus aphids moulted over a period of some hours reach flight maturation at night, wait together until the temperature has risen above the take-off threshold in the early morning (which usually

occurs after sunrise), and fly off all together over a relatively short period. The decline in numbers trapped after this wave is generally due to a lack of alatae mature enough to fly. Later batches maturing more or less together fly off together as "flushes".

The rate at which new alatae are produced by moulting, some hours previously, also affects this basic pattern, for the numbers moulting have a periodicity of their own, and commonly the greatest rate of moulting occurs in the early morning, although this too is variable. Much work has been done at Rothamsted on rhythms of aerial density change and it is now possible, given only the daily temperature charts and the graph of maturation rates with temperatures, to construct theoretically models of flight curves which match those observed in suction traps for the same day.

This story has had considerable effect on the opening up of research. Its major departure from the older views is this: aerial density from hour to hour and day to day is determined more by rapidly changing developmental population processes than by take-off behaviour as influenced by weather. Migration is not confined to calm weather: although high densities are seen near the ground on still days (for the aphids are not scattered by turbulence and convection), these actually add up to fewer insects than on the many occasions of low densities which occur in more windy periods. Thus most dispersal actually occurs when the wind near the ground is *above* the old limit of 5 m.p.h.

## Distribution and Aerial Dispersal

For some years it has been known that aphids and many other insect species, too, reach heights of several thousands of feet. This aerial population (often of astronomical proportions) is regarded by many people as a kind of foam blown off and lost from a main population flying in the lowest air layers. People often ask "are they alive up there?" This so-called "aeroplankton" has never been brought fully into the general picture of the dispersal process and has been considered as a side issue to the main problems. This does not give a true picture of aphid dispersal, and is probably incorrect for many other insects also. At any rate, most aphids, individuals and species, have these aerial excursions; with many it probably occurs several times during their relatively short flying life, which is limited to perhaps less than five days. After this, with the exception of some species [8], the flight muscles autolyse and disappear and the power to fly is lost, although the aphid may continue to live and reproduce for several weeks [15].

Being weak fliers, aphids are carried up and along, and by a process of turbulent diffusion the aerial population becomes thinned out the higher it gets. Its upper limits are almost certainly the convection top—from a few hundred to a few thousand feet depending on the strength of the convection.

Until the work of Hardy and Milne, [9 and 10], Glick [6] and Freeman [5], little attention had been given to these populations high in the air—

out of sight and out of mind. Nor has much thought been given to their significance since then—partly because only their existence was known, and there was a general ignorance of the mechanics and time-table of dispersal in the upper air, as indeed there still is. Recent work at Cardington, however, has shown the functional aspects of these matters, and their great importance is now more apparent.

## Extension of Measurements

The first thing to measure was, not merely the numbers and species caught at a high altitude, but the whole aerial situation from top to bottom in one operation. This was done by measuring aphid density at several heights simultaneously by means of traps on a barrage balloon cable sometimes up to 4,000 ft, meteorological data also being recorded at different altitudes. All this was done in consecutive hourly periods.

Thus, the gradient of aphid concentration and the changes in it throughout the season can be matched against the state of the atmosphere, especially its vertical stability as indicated by the temperature gradient. The insect density gradient thus shows relative densities (i.e., the degree of mixing) independently from absolute numbers which depend on population levels and flight behaviour.

This gradient can be expressed mathematically with great precision and in terms of diffusion theory (Johnson and Penman, 1952; Johnson and Skellam, unpublished). But log Density on log Height gives a very convenient approximation to a linear graph when the regression coefficient ($b$) expresses the slope. Thus a steep curve (high $b$ value) means that relatively more insects are in the lower levels of the atmosphere and *vice versa*. The gradient varies greatly during the season and often even during the day; its value is correlated with the temperature difference between high and low altitudes, which is itself an index of vertical stability of the air.

Thus in relatively unstable air (which is most common) most of the flying aphids are above 100 ft, where, though densities diminish sharply, vast numbers are distributed thinly through a lot of sky. In still air this situation may be reversed and the greater proportion may be in the lower layers.

The hourly gradient throughout the day and night was measured on many occasions. Aphids flying off in the early morning attain maximal densities at maximum heights for the occasion very rapidly—in an hour or two. If the air becomes virtually stable, as it often does in the evening or sometimes in the daytime, the populations diminish very rapidly; the air then clears in an hour or two, or at least the insects leave the upper air and concentrate lower down. It is possible that this may be one reason for the sudden appearance of swarms—"mass migrations"—although more work is required before we can assess the role of atmospheric stability in this.

## Duration of Flight

These facts and several others suggest that the time spent in the air on a single flight by the majority of the aphid population (and this

includes all aphids in the air to maximum heights) is relatively short. At most it is perhaps three or four hours, and with many aphids it is perhaps less. The whole dispersal process is seen as a rapid, continuous turnover of populations in the air, ascending and descending all day. Although nearly all the population leaves the air by nightfall this does not mean they are precipitated at night. We think of upward transport and the ability to take-off causing replenishment during the day and acting against the downward transport by air movement and by gravitational factors which also occur at the same time; but in the evening the former die out leaving only the latter. Wind may thus be important during migration—with *A. fabae* at least, the infestation pattern on a bean field bears a relation to wind direction [14 and 24]. Moreover, in view of the general mixing which occurs, the apparent inability of aphids to identify a host from a short distance, and the strong effect of light breezes on flight direction, it would seem that the danger of close proximity of primary and secondary hosts (e.g., spindle and beans) has been exaggerated. More work is, however, required on this point and there may be times, e.g., in the evening, when proximity does matter.

A small and variable proportion of the population appears to linger up aloft often for some hours after sunset. These add up to considerable numbers and perhaps travel maximum distances, but they appear to be the exceptions.

One important problem, therefore, is to find the probabilities of aphids re-encountering terrestrial habitats once, twice, thrice, etc., during a flight which has taken them through the upper air. This, however, is so intimately linked with the behaviour of aphids during and after flight that we must consider that aspect next.

### Behaviour During and After Flight

We still cannot say how long an aphid stays in the air—neither the mean nor the range of flight duration is known for any species. Up to eight hours tethered flight of *A. fabae* on pins is not a reliable guide to their natural free flight. We therefore do not know how far they usually travel, or, what is more important, how their density falls off with distance from the source of supply. It is known only that some (an unknown and no doubt variable proportion) can go many hundreds of miles [4 and 9], although as mentioned above, the majority probably fly for a very limited time. However, flight is more than a method of getting from place to to place, and some of the most interesting of recent work, by Bruce Johnson [11 and 12], shows that the act of flight—even if only for about twenty seconds—is itself a kind of trigger which in some, probably most, species puts the aphid into a condition in which it will accept for variable periods a leaf which it rejected before flight. Flight, and also other kinds of activity, triggers off parturition in some species which hastens the onset of flight muscle autolysis.

The duration of flight also influences the range of host choice [13], and as Kennedy, Ibbotson and Booth [21 and 22] showed, this may be

largely a matter of leaf age. Thus the time spent in the air and the time of descent may have important effects on the ability to colonize one or another host plant. A landing late in the day may imply an enforced overnight rest, parturition and a hastened autolysis. We do not know if the quality of flight changes with the onset of muscle dissolution. Moreover, the frequency of subsequent flights after the first take-off now has to be seen in the light of turbulent mixing, duration and opportunities for alighting, and the changing physiological state of the insect. These matters are discussed more fully elsewhere [13 and 17].

Thus the questions posed at the beginning of this article have no simple answers at present. We know much more about the elements in the dispersal process; but future work will, no doubt, aim at equating the possibilities of types of behaviour by the individual with the probabilities of their occurrence in the collective situation.

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# Animal Breeding

**Effect of Sire and System of Mating on Estimated Embryonic Loss.** H. W. Hawk, W. J. Tyler and L. E. Casida. *Journ. Dairy Sci.*, 1955, **38,** 420.

In recent years, embryonic death has been recognized as a major cause of lowered fertility in dairy cattle. Predisposing factors for embryonic

mortality and their relative importance are as yet largely unknown. The purpose of this study was to determine the possible effects of sire and system of mating on embryonic mortality up to 5 months of gestation.

A total of 837 services were analysed. The sire had a highly significant effect on the rate of embryonic death in the females to which he was bred. Outbred embryos had an estimated death rate of 19.8 per cent by 150 days, as compared to 22.3 per cent for inbred embryos. Outbred dams had 19.2 per cent embryonic death by 150 days, whereas embryonic mortality in inbred dams was 28.4 per cent. Although the difference between outbreds and inbreds was not statistically significant in either case, the trend was for inbreeding of both embryos and dams, particularly the latter, to increase embryonic mortality.

G.B.Y.
H.P.D.

**Genetic and Environmental Relationships Among Economic Characters in Beef Cattle, I and II.** R. M. Koch and R. T. Clark. *J. Anim. Sci.*, 1955, **14**, 775-91.

This extensive investigation is based on records of Hereford cattle kept at the U.S. Range Livestock Experiment Station in Montana. In general, cows were kept on the native pasture throughout the year with supplementary feed only during severe winter storms or periods of drought.

The most precise method of estimating heritabilities gave values of 35 per cent for birth weight, 24 per cent for weaning weight and 47 per cent for yearling weight. These estimates are much lower than those found by other authors for later gains in feedlot. Weaning and yearling conformation scores had estimated heritabilities of 18 per cent and 27 per cent. The analyses indicated that maternal environment was quite important for birth weight, gain from birth to weaning and score at weaning, but of little importance for yearling gain and score.

Genetic correlation between birth weight and gain up to weaning (0.46) indicates that many of the same genes affect pre-natal and post-natal growth to weaning. Gains after weaning are almost genetically independent of gains up to weaning, and it appears that the growth of an animal once it is weaned is conditioned by different sets of genes. It is suggested that there may be a negative correlation between the genes affecting maternal environment and those directly controlling growth of the calf.

In both pre-weaning and post-weaning periods, the genetic correlations between gains and scores were quite large. In so far as the score measures desirable beef characteristics, there is, therefore, no genetic antagonism between good growth rate and good conformation.

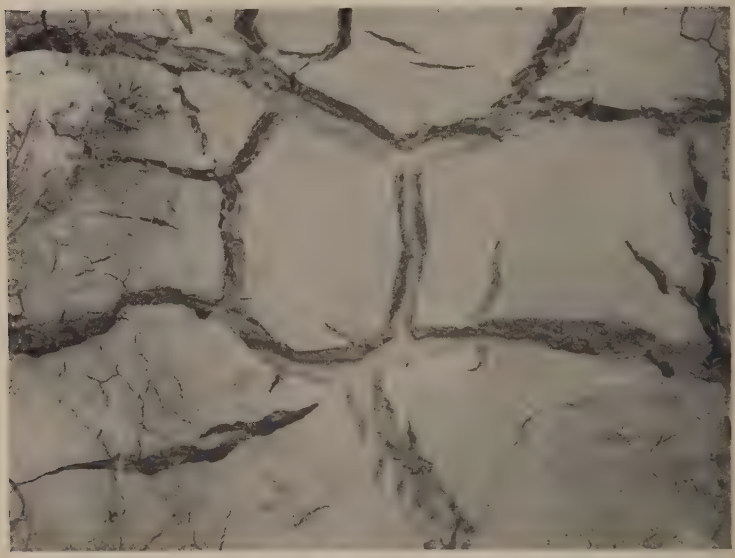
J.W.B.
H.P.D.

Suction traps on a 50 ft. tower.

Large suction trap being assembled for hoisting on balloon.

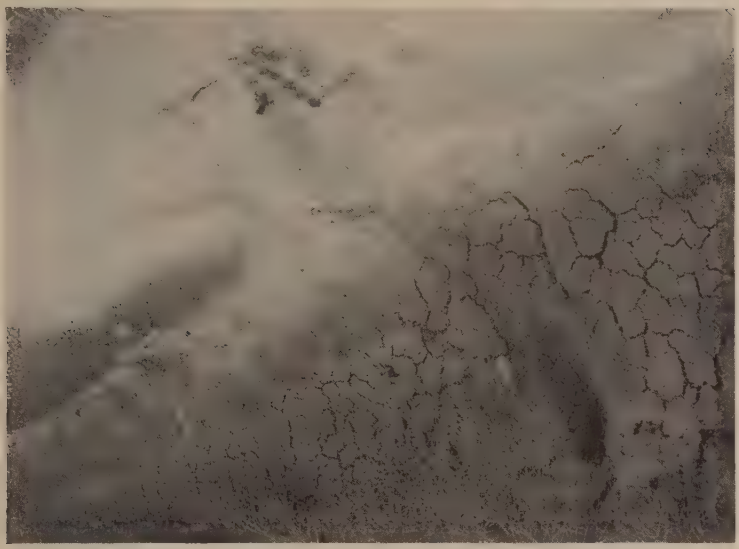
PLATE I

Breakdown of soil structure at surface- note lamination.



Deflocculated clay moving down through surface cracks.

PLATE II



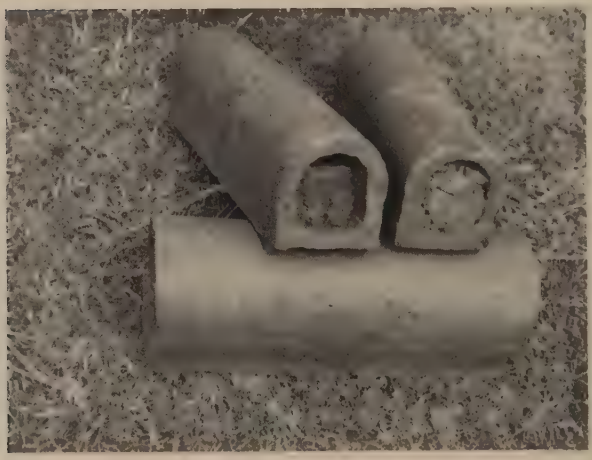
Spewing of deflocculated clay from land drain into open ditch.

Poor knobbly tilth due to loss of surface soil structure.

PLATE III

DETERIORATION OF SEA-FLOODED SOILS
IN LINDSEY, LINCOLNSHIRE (See pp. 87-92)

Ponding due to deflocculation and loss of soil structure.



Drainage tiles choked with fine deflocculated clay.

PLATE IV

**Influence of sex, season of birth and age of dam on economic traits in range beef cattle.** R. M. KOCH and R. T. CLARK. *J. Anim. Sci.*, 1955, **14** (2), 386-97.

The economic traits referred to in the title are birth weight, gain in weight from birth to weaning, weaning weight, and 18 month weight, together with weaning and 18 month scores: 5,952 Hereford calves born between 1926 and 1951 provide the data. Most of the calves were born during April and May, but all were weaned each year on the same day, giving an average weaning age of 26 weeks.

Weight of male calves at birth exceeded that of females by 5.6 lb and at weaning by 26.2 lb: the sexes were alike in weaning scores. Rate of gain from birth to weaning was, for all practical purposes, unrelated to age at weaning, which indicates that, contrary to a widespread impression, there is little difference in growth rate between calves born early and late in the season.

Dam's age had a marked effect on all the characters studied except 18 month score. With each character there was a progressive increase with increasing age of dam from 3 to 6 years, and thereafter a progressive decline; tables are given with which to adjust each character so as to remove the effect of varying age of dam.

A.G.D.
H.P.D.

**A Study of Variation in Twin Cattle. III—Growth.** J. W. B. KING and H. P. DONALD. *J. Dairy Res.*, 1955, **22**, 1-9.

King and Donald make a valuable contribution to the subject of the efficiency of monozygous twin cattle compared with unrelated animals when used in experiments where different nutritional or husbandry regimes are being compared. The relative experimental efficiency represents the number of pairs of unrelated animals that would be required in the place of one monozygous pair if the same accuracy of information is to be achieved. Efficiency values have usually been calculated from monozygous twins only: King and Donald use the wider range of data from an experiment in which monozygous twins, dizygous twins, and pairs of half sisters have been reared in contemporaneous sets, all subject to the same husbandry regime. A more reliable and comprehensive picture was also obtained by converting the frequent regular observations on live weight and height at withers into growth curves. Various aspects of these growth curves rather than observations at any single age are used in presenting and discussing the results.

In nearly all aspects of the growth curves for both weight and height, the similarity of the members of a pair diminished as one moved from monozygous twins to dizygous twins, to pairs of half-sisters, and thence to pairs of unrelated animals; so that instead of having to choose between the extremes of one-egg twins and unrelated pairs, one can, if necessary, select pairs of animals of intermediate efficiency. Experimental efficiency,

however, is only one aspect—although an important one—to be taken into consideration; it must not be regarded as giving a comprehensive assessment of relative merit for experimentation. For example, the validity of a conclusion may depend on the animals used being adequately representative of cattle in general; under such circumstances it would be false economy to use twins. It would be worth while paying the high initial cost of monozygous twins if accommodation were limited, or the cost of treatment high.

Experimental efficiency of monozygous twins is very high for linear growth rate, and only slightly less for average weight or height over the whole period from birth until about 2 years of age, but since the efficiency extends to nearly all aspects of the growth curves, the authors conclude that "the more precise the problem and technique, the greater the cumulative merit of one-egg twins for the restricted purposes under discussion".

A large part of the paper, however, is devoted to genetical problems associated with growth in cattle. The main substance of the genetical discussion could be summed up in this way: that if one works exclusively with differences found in contemporary and uniformly treated sets of monozygous and dizygous twins, there is no reason at present to doubt the validity of deriving an estimate of the main *genetic* component of growth applicable to both twins and non-twins; but that the *environmental* component of growth derived from twins is applicable only to twins; and that therefore the environmental component of the variation among non-twins must be measured directly in non-twins.

St. C.S.T.
H.P.D.

**Some Effects of Inbreeding and Evidence of Heterosis through Outcrossing in a Holstein-Friesian Herd.** R. C. Laben, P. T. Cupps S. W. Mead and W. M. Regan. *J. Dairy Sci.*, 1955, **38**, 525-35.

Inbreeding experiments with dairy cattle have been carried out at three principal centres in the U.S.A.—New Jersey, California and Beltsville Experiment Stations. This paper deals with data from the Californian experiment at Davis in which 164 Friesian cows by 22 sires, were maintained under "constant" environmental conditions. 305-day lactation milk yields, corrected for age and number of daily milkings, have been used and have been expressed in pounds of milk and pounds of fat-corrected milk (F.C.M.). The latter is a conversion of milk yield to a constant energy basis. Persistency of milk production was measured by the slope of a straight line fitted to the mean daily production of F.C.M. per month from the third to eighth month of lactation. Other characters studied were maximum daily milk production and the number of days from calving to maximum daily yield.

Separate calculations of the change in each trait brought about by increases in the coefficient of inbreeding were made from the daughters of each sire; these figures were then added together for an overall estimate.

The coefficient of inbreeding varied from 0 to 44 per cent with a mean of 13 per cent. The greatest inbreeding effect was on milk yield which showed a decline of 209.8 lb for each increase of 1 per cent in the inbreeding coefficient. For each increase of 1 per cent in inbreeding, fat percentage increased by 0.008 per cent, and F.C.M. was depressed by 131 lb. Evidence is produced to suggest that inbreeding may have a smaller effect on production within the range 0 to 15 or 20 per cent, than above 25 per cent.

Inbred offspring of two sires predominated and they were examined separately. No inbreeding depression was apparent up to 20 per cent among daughters of one sire. Inbred daughters of the second sire showed a pronounced decline in milk production, body size and growth rate and an increase in calf mortality. There was also some evidence of sterility. Total yield decline with increased inbreeding was due more to a reduction in the maximum daily yield than to a decline in persistency. Time taken to reach maximum daily yield was not affected by inbreeding.

Twenty-six inbreds averaging 5,366 lb F.C.M. were outcrossed to a third unrelated, inbred sire. The 26 resulting daughters from the cross averaged 10,910 lb F.C.M. which exceeded the production of inbreds and non-inbreds. When these outcrosses were mated to their sire, the offspring averaged 6,146 lb F.C.M. Increased production in outcross daughters is attributed, at least in part, to heterosis.

**Inter-relations of Milk Production and Breeding Efficiency in Dairy Cows.** G. M. CARMAN. *J. Anim. Sci.*, 1955, **14**, 753-9.

From an analysis of 1,646 lactation records in the two herds at Iowa Agricultural Experiment Station it is concluded that first heat in heifers is markedly affected by calendar month. Heifers came into heat latest in March and earliest in September—a consequence of environmental temperature and hours of daylight.

The period from calving to the first heat after calving appeared to be related to level of milk yield in the preceding lactation, but not to yield in the current lactation. The longer service was delayed following calving, the greater was lactation yield. The estimated genetic effect on the characters studied was negligible.

**Variation in Fleece Weight, Weaning Weight and Birth Weight of Sheep under Farm Conditions.** R. L. BLACKWELL and C. R. HENDERSON. *J. Anim. Sci.*, 1955, **14**, 831-43.

Records of fleece weight, weaning weight and birth weight of lambs from the Cornell University flock during the years 1930-1952 have been analysed in order to discover to what extent these characters are influenced by seasonal, maternal and genetic factors. The breeds were Dorset Horn, Hampshire, Shropshire and Corriedale. In view of the Dorset's ability

to lamb in autumn as well as spring, data from this breed were analysed separately. A complicated statistical procedure was used to isolate the effect of several factors on the traits studied because each breed was handled as a one-sire flock with successive rams being bought from outside the flock.

Differences among breeds for each trait were found to be highly significant. Year to year changes in nutrition and general management constituted important sources of variation, but gave rise to no long-term trend. As the age of the ewe increased from 2 to 5 years, the weaning weight of her lamb also increased by an average of 3 lb per year in Corriedales, Hampshires and Shropshires and by 2 lb per year in Dorset Horn lambs. The relationship between age of ewe and birth weight of lamb also showed that the older ewe provided a better pre-natal environment than younger ewes up to 5 years of age. An increase of 0.71 lb per year in birth weight occurred in Corriedale, Hampshire and Shropshire lambs but in Dorset Horn lambs an increase of only 0.27 lb per year was found.

At weaning time, Dorsets were superior in weight for age. The birth weights of Dorset lambs born in Spring were 0.4 lb more than that of autumn-born lambs. At weaning this advantage had increased to 2.85 lb.

Thirty per cent of the variation in birth weight and 42 per cent of the variation in fleece weight were estimated as due to genetic factors in the various breeds. However, the repeatability of birth weight was low and the estimate of heritable variation is probably too high. Weaning weight was only 7 per cent heritable. It is likely, therefore, that individual selection would be worthwhile only for fleece weight.

J.H.W.
H.P.D.

**Problems of Hill Sheep Improvement.** J. MACKAY DONEY. *Proc. Brit. Soc. Anim. Prod.* 1955, pp. 3-12.

This paper discusses the possibility of genetic improvement of a flock of 600 Welsh Mountain ewes kept under typical hill conditions. The investigation is based on records of performance for the years 1949-1955. It is pointed out that in order to formulate a selection programme, it is necessary to decide which successive measurements of any particular character is the most useful. The earlier a good estimate of future production can be obtained, the better. A series of correlations between age and weight, and between weights at different ages, show that June weight of lambs is very significantly correlated ($r = -0.27$) with date of birth, but that weaning weight in September is uninfluenced by age. The weaning weight was quite highly correlated with adult weights, whereas the June weight was not. Heritability (that part of the total variation which is genetic) was estimated for a number of characters, and found to be rather higher than usual, as follows:

| | *per cent* |
|---|---|
| Birth Weight | 39 |
| Weaning Weight | 68 |
| 18 month Weight | 59 |
| Fleece Weight (*first clip*) | 61 |
| Staple Length (*at 20 months*) | 73 |

It is concluded that weaning weight should be given great prominence in a selection programme because of its fairly high heritability, its independence of age, and its significant correlation with adult weight.

Fleece weight, despite its lower heritability is preferred to staple length as a character for selection, since it is strongly correlated with other production characters and more easily measured.

G.W.
H.P.D.

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# Dairy Husbandry

## Milking Intervals

Recent investigations have cast some doubt on the importance of unequal intervals in reducing yield in twice-daily milking, and of the yield advantage of thrice- over twice-daily milking. In past studies of these problems, it has often been difficult to dissociate indirect from direct effects of changed milking regimes, for example, extra feeds in thrice-daily milking. In recent investigations in Britain (G. L. Bailey, P. A. Clough and F. H. Dodd, *J. Dairy Res.*, 1955, **22**, 22), in Australia (H. G. Turner, *Aust. J. Agric. Res.*, 1955, **6**, 145) and in New Zealand (G. M. Elliott and P. Brumby, *Nature*, 1955, *176*, 350), an attempt has been made to find out the length of the period during which milk secretion into the upper udder proceeds at an undiminished rate. The cows were milked at intervals varying from, say, 3 hours up to 24 hours or more, and the yield obtained related to the length of interval. It is possible to remove the confusing effect of different quantities of residual milk in the udder at the beginning of each experimental interval by evacuating the udder before each interval with oxytocin or by milking at several consecutive intervals of the same length. The milk obtained is thus stabilized against milk secreted into the udder for each particular interval studied. In both the Australian and New Zealand investigations, the amount of milk obtained was often directly proportional to the length of the milking interval up to a surprisingly long period, in several cases over 24 hours. On the other hand, in the British experiments the reduced rate of secretion began to appear shortly after the 12 hours' interval. However, the yields were higher and residual milk was not evacuated before each experimental interval. Taking all these investigations together, the conclusion might well be drawn that, over the short term and with low or moderate yields, no substantial advantage would be

gained by avoiding the long night interval of 15 or 16 hours which is common in twice-daily milking.

Some support for this conclusion is provided by more practical experiments in which attempts have been made to compare directly two regimes—one of equal night and day intervals and the other of unequal intervals. In Swedish experiments (E. BRANNANG, *Lantmannen*, 1955, **39,** 837) one-egg twins were used to compare equal intervals of 12/12 hours with unequal intervals of 15/9 and also with 16/8 hours. In the first experiment the unequal intervals resulted in a mean lactation yield only 2.5 per cent below that of the animals on the equal intervals; in the second the depression was 4.1 per cent. The reduction in fat yield was even smaller. In Australia, Turner (H. G. TURNER, *Aust. J. Agric. Res.*, 1955, **6,** 530) used five sets of twin heifers to compare 12/12 hour with 16/8 hour intervals over a period of 16 weeks. In this test no advantage in milk yield was found in the equal interval regime. In fact, the yield was slightly, but not significantly, higher in the animals milked at unequal intervals. These results are quite similar to some which were reported in America many years ago (T. E. WOODWARD, *U.S.D.A. Circ.* 180, 1931), but they should not be used to infer that the irregular interval is without detriment to the very high-yielding cow. Neither should they be used as evidence that there is no inherent advantage to yield in milking three times daily, since there is, so far, no very clear evidence that milking acts as a stimulus to production.

**Hormones and Lactation**

Much study is still devoted to the effect of various hormones on lactation. HANCOCK, BRUMBY and TURNER (*N.Z. J. Sci. & Tech. A.*, 1955, **36,** 571) have investigated the effect of daily injections of l-thyroxine (0.4 mg per 100 lb body weight) during the first six months of pregnancy in one-egg twin heifers. The injections resulted in a reduced rate of live weight gain but an increased rate of skeletal growth. The level of l-thyroxine used appeared to result in a reduction of both milk and butter-fat production at the subsequent lactation.

It is commonly thought that enhancement of milk or butter-fat production by hormonal stimulation is more likely to happen when the cow is in the declining phase of lactation rather than when she is near the peak of lactation. With daily subcutaneous injections of growth hormone, the New Zealand workers (P. J. BRUMBY and J. HANCOCK, *N.Z. J. Sci. & Tech.*, 1955, **36,** 417), however, produced a substantial and significant increase of milk and butter-fat production both at the peak of lactation and also near the end of lactation. At both stages, there appeared to be an improvement in the efficiency of production. A. C. CHUNG (*J. Dairy Sci.*, 1955, **38,** 609) has also reported increased milk production in a very small number of cows as a result of administration of growth hormone a few days pre-partum and post-partum.

A further study of the quantity and fat content of milk left in the udder after normal machine milking has been made by J. H. KOSHI

and W. E. PETERSEN (*J. Dairy Sci.*, 1955, **38**, 788). The residual milk was obtained by a further milking following oxytocin injections in 62 cows at approximately weekly intervals throughout a year. For individual cows, residual milk ranged from 0.7 to 6.1 lb with a mean of 1.8 lb equivalent to 12.2 per cent of the total milk obtained. The fat content of the residual milk was high, and on average amounted to 13.2 per cent. The study provides further evidence of the large reserve of fat retained in the udder of the cow after milking, and emphasizes the importance of this reserve in relation to the efficiency of milking.

### Milk Quality

Further evidence concerning the effect of "fibrousness" of the diet on the fat content of milk has been provided by workers at Shinfield (C. C. BALCH, D. A. BALCH, S. BARTLETT, M. P. BARTRUM, V. W. JOHNSON, S. J. ROWLAND and JILL TURNER. *J. Dairy Res.*, 1955, **22**, 270). On a diet of 2 lb hay and 24 lb concentrates daily, the fat percentage content of the milk was reduced from about 3.5 per cent to below 2 per cent. The addition of 5 lb of dried delignified straw pulp in a finely macerated form brought about no improvement in the very low level of fat, in spite of the fact that the straw pulp contained 66.3 per cent of crude fibre, as analysed by the conventional method. Thus, the physical character of the roughage as well as its fibre content is shown to be of great importance in determining fat levels with this type of ration. Because this work was carried out with two cows, each fitted with a rumen fistula, it was possible to study the rate of passage of the food, the action of the reticulo-rumen, and some of the biochemical changes in the rumen contents. From the data collected, more precise speculation was possible on the biochemical processes involved in the depressing effects on milk fat of diets lacking the property of fibrousness.

At the Hannah Research Institute, rations providing varying levels of starch equivalent and digestible crude protein *above* the conventional (Woodman) standards, were compared. While little effect on milk yield and quality was found in the differing levels of protein, increasing the starch equivalent levels increased yield significantly and resulted in a small but significant increase in solids-not-fat content.

### Calf Rearing

Most calves in Britain are reared indoors until over 6 months old, but in New Zealand the calf is often out-of-doors from birth. In this country, rearing in the open is usually not practicable for the large numbers of calves born in the autumn and early winter, but this may not be so for spring-born calves, if the animal's known ability to graze at a very early age can be matched by a suitable supply of grass. Experiments at Shinfield (J. H. B. ROY, K. W. G. SHILLAM and J. PALMER, *J. Dairy Res*, 1955, **22**, 252) show that, given adequate grass of suitable type, a system of rearing can be devised which results in normal growth

with commendable economy in other food. A number of animals were satisfactorily reared from birth to six months with no other food than 6-8 pints of colostrum, 45 gallons of milk and free grazing. There was little difference in liveweight gain in calves born in February, March or April, but weight gains were greater if they were grazed on leys. The importance of the type of pasture on which young calves are reared is further illustrated in work carried out in Alabama (G. E. HAWKINS, JR. and K. M. AUTREY. *J. Dairy Sci.*, 1956, **39,** 196). Significant differences in liveweight gain were found between calves on the same basal diet, but with one group kept in portable pens on a new ryegrass-clover ley, and the other in portable pens on an old ley frequented by older cattle. The growth rate of the calves on the "clean" ley was over 40 per cent greater than that of the calves reared on "contaminated" pasture.

More data about the relative value of pelleted and unpelleted calf concentrates have recently been reported from Kentucky (C. A. LASSITER, T. W. DENTON, L. D. BROWN and J. W. RUST, *J. Dairy Sci.*, 1955, **38,** 1242). The mixture of concentrates used was the same in two treatments but in one it had been pelleted to $\frac{3}{16}$th-in. diameter pellets. No significant difference in liveweight gains was observed, but where the concentrates were both offered *ad lib* to a group of calves, much greater quantities of the pellets were consumed compared with the unpelleted mixture.

Some evidence has been obtained on the effect of the milk yield of cows which were either suckled for between 45-80 days and subsequently machine-milked, or were milked throughout their lactation by machine. (E. W. SWANSON. *J. Dairy Sci.*, 1956, **39,** 73). In this study, four sets of one-egg twin cows were used, the work being repeated in two sets over a further lactation. One member of each twin was milked by machine throughout the lactation; the other suckled a calf to veal stage and then reverted to machine milking. In the first week after the calves were removed (between 45-80 days after the beginning of the lactation), the suckled twins were found to yield on average about half a gallon per day less than their twin mates. The yield, however, recovered and by the sixth week after weaning they were up to the production of their twin mates which had been machine-milked throughout. It was estimated that the suckling veal calves took, on average, 1,496 lb of milk to increase in weight from a mean of 71 lb to a mean of 194 lb.

### Antibiotics in Calf Feeding

A useful review of the use of antibiotics in calf feeding appeared recently in the United States (C. A. LASSITER, *J. Dairy Sci.*, 1955, **38,** 1102). In general, the main advantages of feeding antibiotics on growth, food efficiency and incidence of scours were found in the first 12 weeks of the calf's life. Improvement in growth rate in older animals had been reported by some workers but this was of little economic importance. For young calves, most evidence has been obtained with aureomycin. Both this antibiotic and terramycin stimulate growth usually from 10 to

30 per cent above control animals. Although penicillin is known to stimulate growth of chicks and pigs under some circumstances, American experiments show either an adverse effect or none at all with calves.

Since this review was published, further evidence of the growth-stimulating properties of aureomycin for young calves has been reported (E. E. BARTLEY, H. C. FRYER, F. W. ATKESON, F. C. FOUNTAINE and J. J. RADISON, *J. Dairy Sci.*, 1955, **38**, 1257). In this work the effect of aureomycin was compared with streptomycin. While the effect of aureomycin was substantial and significant, streptomycin effects on growth were small and not significant. In another trial (E. W. SWANSON, S. A. HINTON, and J. B. MCLAREN, *J. Dairy Sci.*, 1955, **38**, 1385) the effect of aureomycin was less pronounced and more variable; the authors suggest that with liberal milk feeding the response of young calves to aureomycin may be less consistent than on other diets. A.S.F.

# Farm Management

Some farmers have a natural flair for business management: others are not so well endowed. Skill in management depends not only on natural aptitude but also on a constant stream of information to help the farmer to decide on the best line of action. Agricultural economists are providing an increasing volume of such information, the diversity and extent of which is well demonstrated in recent publications about farm mechanization standards, production of individual commodities, feeding standards for cows, and the budgeting of alternative production programmes.

**How Much Mechanization?**

Fresh ground was broken by F. G. Sturrock in four articles in *Farm Mechanisation* during the autumn of 1955[1]. The first article presents a table of "tractor work units" analogous to the "man work units" used to measure manual labour requirements. The table was based upon information on the number of tractor hours used per acre of crops and per head of livestock included in cost studies. Although there is a large measure of flexibility in the amount of work to be expected from a tractor, these figures can be used to predict the number of tractor hours likely to be necessary on any particular farm under average conditions, and so to predict the number of tractors required.

In the second article, Sturrock calculates the capital cost of equipping a farm with implements under modern conditions. Since mechanization can be taken to various levels, three stages of mechanization are recognized: stage one is the minimum list of implements that could be used with a tractor; stage two includes those implements commonly found on an up-to-date farm; stage three could be described as "de luxe" mechanization. At all stages of mechanization, capital costs per acre of tillage implements fall sharply to 200 acres of tillage and then decline more gradually.

It is at once apparent that the small farmer who attempts to buy a full complement of cultivating implements at new prices is likely to burden himself with a very heavy capital outlay. For example, stage three mechanization for 50 acres of tillage would amount to over £13 per acre—and to this must be added the cost of harvesting equipment. The author stated that he knew instances of small farmers being seriously advised to buy a full list of implements which would over-capitalize the farm and seriously increase depreciation costs per acre.

The final articles list equipment requirements and costs for cereals, root crops and hay and silage production, and set out a method of calculating equipment costs for a farm as a whole. Since pasture requires hardly any special equipment, the greater the percentage of pasture the less the cost per acre. As a broad generalization, a top limit of about £30 *per acre of arable land* is suggested for mechanical equipment for a farmer starting in business on a mixed arable farm. If some items were purchased secondhand, the figure could be reduced appropriately. Where a farmer is short of capital and is tempted to spend more than this sum on tractors and field implements he should consider very carefully whether the expense is justified. He might receive a better return on his money if he invested it in more livestock, more fertilizers, or, if he is anxious to save labour, in modernizing his farm buildings.

**Economics of Egg Production**

A large number of useful facts and figures have been brought together by D. H. Lloyd [2]. The financial results (relating to a sample of Yorkshire farms for the year September, 1953, to August, 1954) are now mainly of historical interest, but the tables of physical production standards are of much greater use. These show the typical production and the probable range in production of eggs month by month from a flock commencing lay in September; food and labour requirements; culling and death percentages; and equipment valuations per bird for different systems of management. Further calculations compare the various replacement policies used by poultry farmers, e.g., buying hatching eggs, day-old chicks or mature pullets. The most profitable hatching dates and the problem whether to retain birds for a second year are also discussed. With the help of these figures and the ready reckoners for food and labour costs which are provided, and by making the necessary modifications from farm to farm, an advisory officer could quickly calculate a poultry budget to demonstrate to a farmer whether a poultry enterprise would or would not be profitable on the particular farm. It is the lack of such figures to use as guides which has made budgeting a difficult task for many farm enterprises.

**Beef Production**

A study of relative conditions of fattening cattle on grass or in yards during 1953-4 has been reported by Miss P. P. Richardson [3]. Three fattening methods were investigated in Lincolnshire and Leicestershire—

fattening in yards; wintering in yards and fattening on grass; and out-wintering and fattening on grass. Fattening entirely in yards is shown to be less profitable than finishing the cattle off grass. Of the grass-fattened cattle, the in-wintered herds recorded a loss of 15s. per head, whereas the outwintered herds showed a profit of £5 18s. per head (in both cases the results were exclusive of the value of manure produced). In each system of fattening, the farmers who obtained a high profit paid below the average price for their store cattle, and they received a good increase in value between purchase and sale. Those with the highest profits also had low feeding costs. However, farmers do not always fatten cattle with the object purely of making high profits. In some instances, the manure is required for root crops; there are waste by-products to be utilized; or there is labour available to be used during the winter months. But for whatever reason store cattle are kept, some are kept more successfully than others. The figures in this report are presented in a variety of ways so that they can be modified to suit the circumstances of different farms. By making such modifications, useful advice may be given to many farmers who wish to decide upon the best method of fattening cattle under their conditions.

A similar report of cattle fattening in the South-West in 1954 emphasized the wide range in fattening costs [4]. For each cwt of live-weight gain, total direct costs averaged £4 10s. and ranged from £2 8s. to £6 15s. The average grazing period amounted to 123 days, and during this time the average gain per animal was 1.80 cwt liveweight, equal to 1.7 lb per day. The initial cost and selling prices were important factors in determining the level of profitability between one farm and another. The daily gain in weight was also important in determining the level of profitability. In the five herds having the highest margins per head of returns over direct costs, the daily liveweight gain was 2.1 lb, as compared with 1.6 lb in the five herds with the lowest margins.A comparison was also made between the fattening of South Devon cattle and Devons. This showed an advantage of £1 7s. per head in favour of the South Devons.

**Sheep**

Input/output relationships for breeding and fattening sheep in the South-West have also been reported from Bristol University [5]. The average margin for breeding flocks for the years 1952-53 and 1953-54 averaged £5 6s. per ewe put to ram, ranging from a loss of £1 3s. per ewe to a margin of £7 8s. per ewe. The number of lambs reared per ewe was found to be an important factor influencing the level of profitability. On the five farms with the lowest lambing percentages (an average of 0.88 lambs reared per ewe) the margin was £2 10s. per ewe. On the farms with the highest lambing percentage (1.30 lambs per ewe) the margin averaged £5 15s. per ewe. The flocks with the highest lamb percentage were fed at a relatively higher plane of nutrition; approximately $3\frac{1}{4}$ lb

more concentrates and 34½ lb more hay being consumed per ewe than on the low percentage farms.

A study of winter-fattening of sheep showed a distinct financial advantage in selling shorn sheep rather than unshorn sheep sold slightly earlier (the margin per hog for the unshorn flocks was 4s. 2d., compared with a margin of £1 10s. per hog for the shorn flocks). It must be remembered, however, that the more remunerative system normally makes demands on land and labour during the busy spring season and may retard cultivations and sowing dates. The most important item of cost during the winter-fattening period was that of forage crops, and considerable advantages were shown in favour of growing kale rather than swedes as a winter forage crop. The food and labour requirements, the liveweight gains, the size and wool clip, etc., were shown for a variety of breeds and circumstances.

**Feeding Dairy Cows**

Fuel is added to the present controversy over feeding standards in milk production by a recent article by M. B. Jawetz [6]. For a number of years economists have been criticizing the standard feed requirements which assume a constant ratio between feed inputs and milk production (e.g., 2.5 lb S.E. per gallon). In this article Jawetz reviews British, American and Scandinavian work on this subject and clearly demonstrates the increases in feed requirements per gallon which occur as milk yields increase. The marginal feed requirement (i.e., the feed required to produce the final gallon of milk) may be as high as 12¾ lb S.E. per gallon for yields between 900 and 1,000 gallons. It follows that the maximum milk production is not necessarily the most profitable, for the value of the extra milk produced may be less than the cost of the feed used in producing it. Furthermore, the most profitable level of production will vary as the ratio of feed price to milk price varies. With the present high prices of concentrates, it is necessary to give careful thought to the question whether some farmers are reducing profits by forcing too high yields from their cows.

**Principles of Adjusting Farm Programmes**

A valuable illustration of farm planning techniques is given in a study conducted on 241 dairy farms in New England[7]. As Wheeler and Black say in their introduction:

> "The primary objective of this volume is to provide a better understanding of the changes in organisation and management which can be expected to contribute to the more successful operation of New England dairy farms over the next decade or more. . . . In so far as interest is concentrated on money income prospects, the problem is mainly one of estimating differences in future receipts and expenses of the farm business under two or more alternative management plans. *Comparative budgeting* is a useful tool for this estimating process and it is a tool which is used frequently in this book."

After some introductory chapters describing the general characteristics of the region, the land and the farms, the possibilities of increasing forage production on one typical farm were discussed. After a review of the existing situation, some eleven alternative programmes were presented, each of which was carefully budgeted, and the advantages of the most profitable programme for forage production were demonstrated. The succeeding chapters discussed the many other management opportunities facing dairy farmers—size of the dairy herd, optimum milk yield, seasonality of production, raising of replacements, addition of supplementary enterprises and so on. Even the possibility of leaving dairy farming and working elsewhere was discussed. The final chapter summarized the procedure for comparative budgeting and listed three types of basic information required:

The present situation, including physical and financial resources available, cropping programmes, the livestock programme, rates of fertilization, rates of feeding and other management practices;

The range of technical possibilities for varying the management of present enterprises on the farm or for adding new enterprises;

The expected price relationships for the period of time covered by the analysis.

The main value of the book to management advisers in this country lies in its demonstration of the usefulness of budgeting in solving individual farm problems, but it also shows how the same tools can be used by the research worker in framing solutions to regional agricultural problems. If the principles of budgeting are soundly understood, and if use is made of the basic information which is being supplied from many quarters, farm management advice in this country can also make substantial contributions to improving the use of national resources in agriculture.

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A.J.
L.N.

# Applying the Hybrid Corn Method to Other Crops

MOST AGRICULTURISTS are by now familiar with the fact that substantially increased yields of maize have been obtained by the replacement, throughout the Corn Belt of the U.S.A., of open-pollinated varieties by double-cross hybrids. More and more plant breeders are considering the possibilities of obtaining similar increases in other crops.

## The Hybrid Corn Method

Development of hybrid corn (maize) varieties proceeds in four stages. The first stage is the tedious one of prolonged inbreeding to produce highly homozygous lines. The second consists in making single crosses between these lines and observing their performances. This serves to evaluate the inbred lines, but the single crosses are not themselves the product ultimately released to the farmer: single-cross seed, being produced on low-yielding inbred lines, is too expensive for commercial use. The farmer is supplied with seed of a double cross, the product of crossing two single cross hybrids. The third stage is therefore the testing of particular double crosses. Finally, after extensive regional testing of the more promising double-crosses the hybrid seed is produced on a commercial scale.

A commonly held misconception about the hybrid corn method is that it was successful because it allowed the breeder to utilize heterosis or hybrid vigour. It is, of course, true that it does this, but it is also true that other methods of breeding a cross-pollinated crop like maize must also utilize heterosis or hybrid vigour. The particular reasons for the success of the hybrid corn method have been discussed by Fisher [1] who notes that "hybrid corn has been an immense success in that species, in which thousands of inbred lines have been produced"; but that "in species in which so far only a few inbred lines have become available, success has not been conspicuous". Fisher continues by suggesting that "when many homozygous lines are available the conditions for effective selection seem to be at their best". He also points out that in the hybrid corn method "(i) we are selecting the actual genotype to be used for production, not merely an ancestor of it; (ii) owing to the reliability of breeding performance achieved by inbreeding, lots of all sizes will be available for testing (many crosses get no further than a first inspection, but promising crosses may be tested in quantity with all the precision which modern experimental design makes possible) ; and (iii) any special advantage, limited perhaps by locality or by industrial use, remains a permanent property of the hybrid, which will reappear wherever it is made up".

### Difficulties with Other Crops

The characteristic difficulty in applying the hybrid corn method to other crops is purely a technical one. In maize, the pollen is produced by staminate flowers borne on the "tassel" at the apex of the plant, while the ovules are produced by the "ear" in the axil of a leaf. This makes large-scale controlled pollination particularly easy. In most other crops the pollen and ovules are produced by the same flowers and controlled pollination is far more tedious.

Even so, there are cases where it is economically feasible to produce hybrid seed by emasculation and controlled crossing of individual flowers. The necessary conditions are that each flower must be capable of producing many seeds, and that the cost of the seed must be a relatively small proportion of the total cost of growing the crop. Examples of crops fulfilling these requirements are tobacco and tomato. The John Innes Horticultural Institution has this year released on a commercial scale two tomato hybrids: Ware Cross and Hertford Cross. The investigations leading up to these hybrids have been summarized by Haskell and Brown [2]. Here the method has been applied to a crop which is normally self-pollinated and the heterosis effect is, as it were, a bonus. The inbred lines were already available as commercial varieties, and the problem was to find crosses which would consistently outyield good commercial varieties. As a result of trials from 1940 to 1949 the choice fell on Potentate $\times$ Leaf Mould Resister 1 (Hertford Cross) and Potentate $\times$ E.S.1 (Ware Cross). A commercially important feature of these hybrid tomatoes is their early cropping.

When the expense of emasculating individual flowers would be prohibitive, the best hope of producing crossed seed on a commercial scale is to use some genetical method. Several of these methods have been suggested, but priority has been given to the use of male sterility, which amounts to genetical emasculation.

### Sugar Beet and the Use of Male Sterility

The use of male sterility for the production of hybrid seed is seen at its simplest with sugar beet. Given two inbred lines, one male sterile and the other male fertile, capable of producing a superior $F_1$ hybrid, the production of hybrid seed would be merely a matter of planting together rows of each inbred in such a way that enough pollen is available to pollinate the male sterile, and that the seed from the male sterile can be harvested separately. Since this seed will be used to produce a crop of roots, it will be a matter of indifference whether it produces male sterile plants or not. The chief problem to be solved is the production of an inbred line which is male sterile and a good parent. This involves producing a range of male sterile inbreds for testing, a task which involves some knowledge of the inheritance of male sterility.

The majority of plants are male sterile only if they have the right combination of Mendelian (chromosomal) and cytoplasmic factors. The

Mendelian factors favouring male sterility are usually recessive, and so if a male sterile is pollinated by a line homozygous for these recessives, the progeny are male sterile; in this way the male sterile line can be maintained, provided the appropriate pollinator is also maintained. To develop other male sterile inbreds, it is necessary either to find other unrelated plants which also carry the appropriate recessives or, failing this, such lines have to be bred. Once such lines are available, their chromosomes can be transferred to the "male sterile" cytoplasm by back crossing. Without going into any more detail, it will be evident that the mere production of a range of male sterile inbreds is attended by difficulties which did not trouble the hybrid corn breeders. Presumably this is why the application of the method to sugar beet has been so slow. The work seems to be most advanced in the U.S.A. (cf. Owen [3, 4]; Stewart and Campbell [6]), but so far no hybrid sugar beet variety is commercially available.

**Sorghum and the Hybrid Corn Method**

Turning now to crops in which the product harvested is the seed, a further complication arises: here the commercial seed supplied to the farmer must not produce male sterile plants, for this would seriously reduce crop yields. A solution found by sorghum breeders in Texas has been described by Quinby and Martin [5]. They use a male sterile line, which we will call A, and two kinds of pollinators, of which B is male fertile because it has the wrong cytoplasm, while C is male fertile because it has the dominant Mendelian factors. A crossing plot in which A and B are planted serves to maintain the male sterile line, since all seed harvested from A gives rise to male sterile plants. To produce commercial seed, the male sterile seed from the first crossing plot is planted with rows of C as a pollinator. This produces, on the male sterile rows, seed which will give hybrid, male fertile plants. Since one pollinator row can produce enough pollen for twelve 40-inch rows of male steriles, the wastage of seed on the crossing plot is fairly small, and it is not expected that the hybrid seed will be much more expensive than ordinary certified seed.

Sorghum belongs to the class of crops which are mainly self-pollinated, but have several per cent of cross pollination. The ordinary commercial crops therefore owe little of their yield to heterosis. The grower of hybrid sorghum can expect an extra yield due to heterosis of some 20 or 30 per cent. This achievement of the Texan sorghum breeders is a great encouragement for breeders working on other crops of this type: an example in this country is afforded by field beans.

To sum up, the hybrid corn method was an outstanding success in its original application to maize, because it allowed maize breeders to test the performance of different genotypes with the same precision as had been available to the breeders of self-pollinating crops or clonally propagated crops. The application of the method to other cross-pollinating crops is possible in principle, but in practice it requires the

development of some genetical method of controlling pollination, such as the use of male sterility. The method can also be applied to self-pollinating crops to obtain a bonus of extra yield due to heterosis.

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J. L. F.

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# Commonwealth Agricultural Bureaux Publications

BUREAU OF ANIMAL NUTRITION

**Nutrition Abstracts and Reviews, Volume 25, Nos. 1 & 2**

*Abstract 1382* reports an attempt to link the data from manurial experiments on small grass plots with the findings for milk yield on pastures of known manurial history. The relations of available N and yields of dry matter and S.E. per acre, to carrying capacity and milk yield per cow per acre are expressed graphically. Of the two methods of raising production, that of increasing the yield of grass and so the carrying capacity may be more effective than raising the milk yield per cow in herds that average 600 gal per cow and 150 gal per acre.

*Abstract 1407* deals with the improvements that have been noticed in Germany in fattening tests with pigs. Before the war, pigs were eating anything from 2.8 to 6 kg fattening ration per kg weight increase. In tests at the Animal Breeding College at Giessen up to 1944, the range was 2.86 to 5.76 kg per kg weight gain. In two years since the war a standard of not more than 3.8 kg has been set, and of 49 groups tested, 28 attained it with an average of 3.53 kg. An enormous saving in feeding-stuffs would result if only the most efficient pigs were used.

*Abstract 1390*. Investigations in Canada have shown that the synthetic oestrogen, diethylstilboestrol, given as an implant to young lambs, increased the moisture content of the tissues and the proportion of offal in the carcass.

**Nutrition Abstracts and Reviews, Volume 25, Nos. 3 & 4.**

Food consumption economics have been the subject of some interesting papers. In the U.S.A. the studies (*Abst.* 4065) have aimed at finding outlets for the surpluses which are at present accumulating. If each lower

income group up to the level of $7,500 could be induced to adopt the habits of the group next above it, the problem of surplus stocks of dairy products would be solved immediately. Some of the changes in consumption, such as those involving fresh vegetables and dairy products, would improve nutrition. But a change of this kind would not solve all the problems. Some manipulation of prices and policies would be needed to encourage the growing of grains for livestock and of fruit and vegetables at the expense of cotton, tobacco and wheat.

It is of interest that one writer (*Abst.* 5947) has discussed the change in cereal consumption that is taking place in Japan. He indicates the opportunities that await American producers in the Japanese market as a result of increasing population and the preference for wheat over rice.

Studies in the Netherlands (*Abst.* 4067) have shown that the consumption of visible fats in that area tends to increase; about 60 per cent of the total fat is consumed in that form. Butter has been replaced to such an extent that it now provides only 5 per cent of the total fat, compared with 12 per cent before the war; margarine, on the other hand, instead of providing 15 per cent, as it did before the war, now provides 35 per cent of the total fat.

In Britain there is evidence that the pattern of production has not returned to its pre-war form (*Abst* 5946). In 1949-50 the proportion in which total calories were derived from crops and from livestock was estimated to be 59 and 41 per cent respectively. In 1939-40, the amounts were 47 and 53 per cent. Some measure of the change that has occurred is provided by the data for the war year 1943-44, when the amounts were 71 and 29 per cent. Mechanization has, *inter alia*, set free for increased food production about 1 million acres formerly required to maintain farm horses.

BUREAU OF PASTURES AND FIELD CROPS

### Methods of Surveying and Measuring Vegetation

D. Brown, 1954, 240 pp., quarto, cloth bound; illustrated with half-tones, line drawings and tables; index, glossary, bibliography; 35*s*.

Parts I, II and III of this book were reviewed in numbers 26, 27 and 28 of this Review.

The principle underlying the final section (Part IV) of this Bulletin is the conservation of a natural resource; in this case vegetation. Although the principle holds good for the harvesting of any naturally-occurring crop, the techniques described are those for determining the actual and the optimum use of vegetation by grazing in regions where the continued production of forage is menaced by heavy grazing.

# Provincial Note

## Weather and the Incidence of Chocolate Spot on Beans

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CHOCOLATE SPOT on beans (*Botrytis fabae*) was widespread during a number of war years in Gloucestershire, Wiltshire, Somerset, Dorset, Devonshire and Cornwall. As a result, experimental work on this crop during the years 1948-52 was considerable. Although there were mild attacks of Chocolate Spot during this period, it was never sufficient to reduce yields appreciably over wide areas. Experiments were discontinued in 1952, but in 1953 bad attacks were experienced in many parts of the Province and some crops had to be ploughed in. Because it seemed likely that the occurrence of the disease had some relation to weather, the following investigation was undertaken for the period 1942-53, using the existing biological and meteorological information.

A relation between high humidity and the occurrence, or spread, of many plant diseases, e.g., potato blight is generally accepted [1, 2 and 3]. Linke [4] has also suggested that the frequency of hours with a relative humidity approaching 100 per cent could be used with advantage in bioclimatology. Hygrograms were available for Bristol (Whitchurch or Filton) for most of the period and these have been analysed to give the number of hours in each month when the relative humidity was 95 per cent or more, i.e., the number of near-saturation hours. The values, after adjustment for missing records, are given in the following table :

**Table 1**

**Hours per Month with Relative Humidity ≥95% at Bristol, 1942-53**

| Year | March | April | May | June | July |
|---|---|---|---|---|---|
| 1942 | 195 | 41 | 112 | 90 | 94 |
| 1943 | 215 | 125 | 137 | 133 | 159 |
| 1944 | 73 | 170 | 58 | 90 | 142 |
| 1945 | 148 | 151 | 185 | 137 | 140 |
| 1946 | 76 | 128 | 97 | 205 | 101 |
| 1947 | 29 | 85 | 150 | 134 | 134 |
| 1948 | 127 | 83 | 81 | 70 | 53 |
| 1949 | 117 | 97 | 61 | 78 | 55 |
| 1950 | 158 | 52 | 123 | 131 | 203 |
| 1951 | 187 | 60 | 182 | 129 | 119 |
| 1952 | 199 | 112 | 159 | 124 | 54 |
| 1953 | 161 | 22 | 58 | 197 | 125 |
| Mean | 140 | 94 | 117 | 127 | 115 |

Table 1 gives the mean for each month. To facilitate comparisons, the values in this table have been expressed as percentages of their corresponding means, and are given below.

**Table 2**

**Number of Hours per Month with Relative Humidity ≥95 per cent expressed as a Percentage of the Mean for the Month.**

| Year | March | April | May | June | July |
|---|---|---|---|---|---|
| 1942 | 139 | 44 | 95 | 71 | 82 |
| 1943 | 153 | 133 | 117 | 105 | 138 |
| 1944 | 52 | 181 | 50 | 71 | 124 |
| 1945 | 105 | 161 | 158 | 108 | 122 |
| 1946 | 54 | 137 | 83 | 163 | 88 |
| 1947 | 21 | 90 | 128 | 106 | 117 |
| 1948 | 90 | 89 | 70 | 56 | 46 |
| 1949 | 83 | 103 | 52 | 61 | 48 |
| 1950 | 113 | 56 | 105 | 103 | 177 |
| 1951 | 133 | 64 | 156 | 102 | 103 |
| 1952 | 142 | 119 | 136 | 98 | 47 |
| 1953 | 115 | 23 | 50 | 156 | 108 |

The values given in Table 2 are plotted in Fig. 1. Broken lines indicate 90 and 110 per cent of average, and all values between these limits have been regarded as average. For ease of expression, all months with more than 110 per cent of average of near-saturation hours are called "moist", and those with less than 90 per cent are called "dry".

Biological data consist of an annual assessment of the disease, referring particularly to Somerset and Gloucestershire, i.e., to those parts of the S.W. Province nearest the sites of the meteorological instruments. Reports, up to 1947, on beans grown at Somerset Farm Institute, Cannington, were also used. The nature of the biological data precluded any statistical methods of comparison with the humidity data, and the two sets of data were therefore compared year by year for any apparent relationship. To aid this comparison, remarks concerning the disease are shown on the diagram when practicable, i.e., when the year was notably free from Chocolate Spot, or when the onset of disease was clearly defined.

The table on pp. 90-91 assesses the extent of the disease from the years 1942 to 1953 and shows the apparent relationship between its occurrence and periods of high humidity.

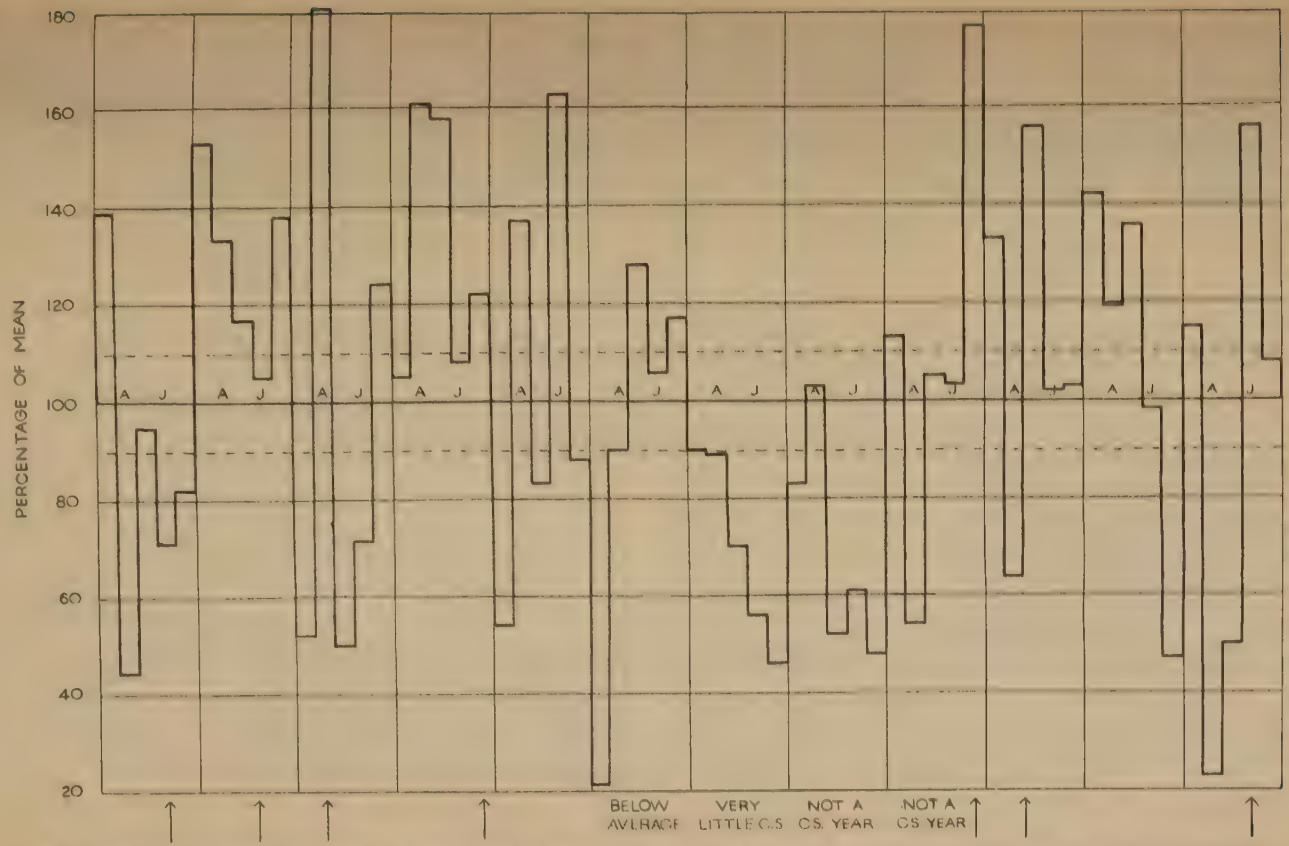


Fig. 1. Frequency of hours with relative humidity ≥ 95 per cent, expressed as a percentage of the monthly mean March-July, 1942-53.
April and June are marked for each year. Arrows show the onset of Chocolate Spot when known.

**Relationship Between Chocolate Spot Outbreaks and High Humidity**

| (1) Year | (2) Disease Assessment* | (3) Periods of Humidity | (4) Relationship between Columns 2 and 3 | (6) Remarks |
|---|---|---|---|---|
| 1942 | Cases prevalent from June 11 onwards | "Moist" March | No evident relation | Chocolate Spot became prevalent during "dry"period |
| 1943 | Extremely prevalent and severe in Somerset, Wiltshire, and Gloucester. Autumn-sown crops most affected. Damage severest where there was potassium deficiency | "Moist" season, except in June | Apparent close relation | Disease favoured by prolific growth and wet periods in May and June. Further damage caused by Rust. In Somerset the two diseases caused 70 per cent loss of crop. Beans in mixed corn less severely damaged |
| 1944 | Widespread in early April, subsequently checked by drought | "Moist" April, otherwise dry until July | Close relation | |
| 1945 | (*a*) *General.* Started in July, but made little headway except in low-lying localities where growth was dense<br>(*b*) *Cannington, Somerset* Disease started in early June | April, May and July "moist" | Taking Col. 2 (*b*) into consideration, close relation | |
| 1946 | Generally distributed; widespread by end of June, but pod formation fairly good | "Moist" April and June | Attack associated with "moist" June, but not with April. Fair relation | Despite prevalence of disease in July, good crops were harvested in well-exposed situations where nutrition was satisfactory |
| 1947 | (*a*) *General.* Slightly less than usual<br>(*b*) *Cannington, Somerset* Disease appeared in late May but did not spread much | A "dry" start followed by slightly "moister" season than usual. No very "moist" months. | *Col.* 2 (*a*) Reasonably close relation<br>*Col.* 2 (*b*) A much closer relationship | |

| (1) Year | (2) Disease Assessment* | (3) Periods of Humidity | (4) Relationship between Columns 2 and 3 | (5) Remarks |
|---|---|---|---|---|
| 1948 | Very little Chocolate Spot | All months "dry" | Close relation | |
| 1949 | No disease | All months "dry" except for average April | Close relation | |
| 1950 | No outbreak, but during rainy spells in July foliage blackened and quickly died off | "Moist" July | Blackening and dying foliage coincided with very "moist" July. Close relation | |
| 1951 | Developed from end of April to June | March and May "moist", April "dry" | Development of disease from May onwards shows fairly close relation | Disease not markedly aggressive; generally, good crops were obtained |
| 1952 | Aggressive Chocolate Spot developed and persisted from May onwards | March-May "moist" | Fair relation | Thunderstorms and heavy rain occurred in the 1st week of May, temperatures (55-60° F) exceeded normal, after which October-sown broad and field beans succumbed to aggressive Chocolate Spot. Several badly affected fields were abandoned. Many crops from later sowings outgrew the disease |
| 1953 | Slow development of disease, becoming aggressive during wet periods towards end of June in under-nourished fields | March and June "moist", particularly the latter month | Close relation | Some crops were ploughed in |

*Where relevant, crop reports from the Somerset Farm Institute are given.

## Results

1. In eight of the twelve years investigated there was a close relation between occurrence of the disease and the frequency of near-saturation hours.
2. Three of the years (1946, 1951 and 1952) showed at least a moderately close relation.
3. 1942 was the only year when no apparent relationship was established.

These results indicate fairly conclusively that the incidence of Chocolate Spot is related to the frequency of near-saturation hours.

Conclusions are based on relative frequency of "moist" and "dry" months. Disease incidence possibly depends on a threshold value of near-saturation hours, but further work—preferably on the occurrence of the disease in one particular area, instead of over several counties—would be needed to establish this. It is possible that the onset of Chocolate Spot, like potato blight, is predisposed by the occurrence of a certain period when the relative humidity is continuously above a given limit. The relative-humidity relation may also be connected with other weather factors not considered here, e.g., temperature. An analogous connection exists between potato blight and both relative humidity and temperature. Large (1953) states that a "critical period", which generally precedes the first outbreak of potato blight by 7-21 days, is defined by a period of at least 48 hours in which the temperature is not less than 10° C and relative humidity not below 75 per cent.

The precise value of 95 per cent used for relative humidity in the present investigation may not be important. Measurements were made in a Stevenson Screen at well-exposed sites and therefore cannot be taken as referring to the humidity within or just above the crop. However, variation in the frequency of near-saturation hours based on the standard data probably runs closely parallel to the variation of another humidity factor within or near the crop.

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Thanks are due to Mr. L. G. Ogilvie who provided the annual disease assessment and discussed plant disease and weather problems; to Mr. G. E. Furze who supplied information on the bean crop at Cannington; and to Mr. J. W. Davies who gave invaluable assistance in extracting data from daily hygrograms.

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